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THE EFFECT OF TYPICAL ENAMELS ON COLORS OBTAINED WITH VARIOUS STAINS

The production of colored enameled ware is becoming of increasing importance in the enameling industry. Enameled advertising signs, in which the greatest range of colors is used, have been an article of manufacture for many years, but more recently colored enamels have found extended application for stove parts and metal household and restaurant furniture. Considerable care is required in the preparation of the various desired shades and tints and much difficulty is encountered at times in their duplication. This may be due in some cases at least to composition of the enamel base and to treatment in application.

The compositions of the coloring oxides are also of extreme importance, and since very little information is available concerning these, either in the literature or elsewhere, it was essential that they be studied in connection with effects on color encountered by the use of typical enamels. A number of coloring oxides, comparing very favorably with those now used in standard commercial practice, were developed from trial tests. These were used in three typical enamel formulas of varying compositions and of the commercial type. Later some of the oxides were added to batches of a series of enamels which were designed to show the effect of systematic changes in composition of the rift upon the finished color. Some colored enamels were made by mixing the color-producing elements with the raw batch before melting; for example, blue and black. Other colors were added to the frit at the mill before grinding. Some of the more important results are as follows:

1. When additions of coloring material are made before smelting they should be very thoroughly mixed with raw batch to insure uniform results.

2. Slight variations in tint of the coloring oxides may affect the shade of the resultant enamel and may be corrected by adding more or less of the oxide, as the case may be.

3. Calcined alumina may be used as a body or diluting medium in the preparation of oxides, but an excess will affect the gloss and texture of the finished product.

4. In order to duplicate any oxide it is necessary that procedure and conditions remain constant.

5. The clay addition to the mill batch should be reduced to a minimum and compensated for by finer grinding in order to eliminate "scumming" of the fired surface.

In order to correlate the results of this investigation with plant practice it is planned to use laboratory prepared colors in the production of commercial enamels under plant conditions.

THE ABRASIVE HARDNESS OF CERAMIC GLAZES

A method[1] has been developed for determining glaze hardness which may be used to compare different brands of commercial ware. The average hardness of 10 brands (4 foreign and 6 domestic) of hotel dinner plates was determined to illustrate the usefulness of this method to purchasers of chinaware.

The observations outlined in Technical News Bulletin No. 103 have been

[1] See Technical News Bulletin No. 97, p. 7.

confirmed; that is, hardness (a) varies in direct proportion to the silica content, (b) reaches alternate maximum and minimum as alumina content is increased, and (c) reaches a maximum as glaze thickness is increased. Further data have been obtained which indicate that, other conditions being constant, (a) increasing firing temperatures by two cones (40° C.) or more materially increases the hardness of those glazes which mature with difficulty at the lower temperature, and somewhat increases the hardness of well-matured glazes; (b) the hardness of well-matured glazes increases, in most cases, as thickness decreases down to 0.04 mm., the thinnest glaze studied; (c) the maximum hardness value of a glaze is obtainable only by properly selecting the firing temperature, thickness, and body; (d) the most resistant of the experimental glazes used in this investigation were within a relatively narrow composition limit; and (e) a glaze becomes more easily abraded as its tendency to "matt" increases.

The results of the tests on hotel chinaware showed that some brands of vitreous ware were decidedly and consistently harder and more uniform in quality than others; one foreign semivitreous brand was found to be the softest and most irregular in quality of the whole group. The six domestic vitreous brands graded fairly uniformly between the foreign semivitreous and vitreous. Of the 10 wares tested, the maximum hardness found was 50 per cent greater than the minimum.

Although this investigation does not involve a complete study of glaze hardness, enough information has been obtained to point out the fundamental factors of composition, manufacture, and other physical conditions which influence the quality of white-ware glazes.

PROBLEMS RELATING TO SAGGERS

A second progress report on this investigation has been forwarded to the editor of the Journal of the American Ceramic Society for early publication. This report describes briefly the development of an apparatus by means of which the thermal expansion of sagger clays can be determined rapidly and with satisfactory accuracy. The paper also reports the results of the linear thermal expansion determinations, together with some observations of the expansion characteristics and of the apparent relation of thermal expansion to porosity and resistance to failure in an air-quenching test. For a few clays, the effect of repeated burns and of additions of artificial corundum on thermal expansion were also studied.

The thermal expansion of 49 clays was observed, the data collected indicating that there are two distinct types of clays as regards thermal expansion and resistance to sudden temperature changes. One type includes clays which expand very rapidly between 100 and 200° C. and crack or dunt below 500° C. in an air-quenching test; the other type includes clays of average expansion between 100 and 200° C. and which fail in the air-quenching test at temperatures above 500° C. The inversions of uncombined silica were sharply defined in some cases and barely discernible in others. It was also shown that repeated burns tend to decrease the expansion between 500 and 600° C. and increase the expansion between 100 and 200° C., indicating a resultant decreased resistance to sudden temperature change.

The data indicate that more caution is advisable in cooling a kiln at lower temperatures if it is desired to prolong the life of the sagger. In present practice it is generally considered safe to tear out the wickets after the kiln is "black" and permit the cooling to proceed as rapidly as possible. Thermal expansion observations indicate clearly that there is not only a greater expansion from room temperature to 500° C. than from 500 to 1,000° C., but that for the majority of the clays the expansion rate may be very high at temperatures which are referred to as merely "warm" (100 to 200° C.). Furthermore, it is indicated that the expansion behavior in this low range materially affects the life of the sagger.

PHYSICAL DATA ON COMMERCIAL BUILDING LIMESTONES

Limestone is more extensively used as a building material than any other type of natural stone, and the bureau is frequently called upon for up-to-date information concerning the physical properties of the various producing quarries. For the past three years efforts have been concentrated on collecting and testing representative samples from different producing districts to complete the available data and form the basis of a report on this material. The report which is now being compiled will contain considerable information not heretofore available on the greater portion of this product. Properties of stone not generally studied but of considerable interest in a structural way are elasticity, shearing strength, and permeability. Since the usual testing equipment is not well adopted to such determinations on stone it was found necessary to design and construct apparatus for these tests.

For the typical limestones the range in modulus of elasticity results is from 3,300,000 to 5,400,000, while for those very dense limestones approximating the texture of marble this property ranges from 7,000,000 to 11,000,000. Shearing strength for the first group ranges between 800 and 3,000 lbs./in.[2] and for the second group 3,000 to 4,400 lbs./in.[2] Permeability results determined on the basis of the quantity of water flowing through a one-half inch thickness of stone 1 square foot in area indicate values varying from 1 cubic inch per hour for the average limestones.

An investigation is in progress to determine if limestone under considerable stress finally yields by fatigue under a much smaller load than is indicated by ordinary tests. This question has been studied from the point of compressive and bending stresses. Fatigue tests indicated that 60 per cent of the samples rupture in a short time when submitted to a flexural stress equal to 80 per cent of the indicated strength.

Probably the most important tests made were those to determine the relative resistance of the different materials to frost action. A somewhat different procedure was adopted for this purpose, which involved determining the number of freezings and thawings necessary to destroy the different materials. As compared with the usual manner of performing this test the time required was very long, and the process would not be at all feasible for ordinary routine tests. These tests, while intended primarily to compare the weathering qualities of different limestones, are expected to supply the necessary data to enable one to judge more intelligently the weathering qualities of stone from simpler tests. The less resistance limestones disintegrated in less than 100 freezings, while some of the more resistant grades have passed 2,500 freezings and show only a slight amount of decay. Copies of the official publication giving the results of this work will not be available for distribution to the public for some six or eight months.

EFFECT OF CERTAIN MATERIALS IN THE FINISH COAT OF PLASTER

In February, 1922, there were erected at the bureau 98 panels of plaster, in the finish coat of which were incorporated various materials which were selected as being likely to cause trouble if present. This investigation was sponsored by Committee C–7 on Lime of the American Society for Testing Materials; the panels erected by the Contracting Plasters' National Association; the materials furnished by the National Lime Association; the plaster applied by the Operative Plasters' International Union; and the bureau conducted the necessary laboratory work, furnished the space for the panels, and made the examinations of their condition. A report indicating the procedure employed in the erection of the panels, the ingredients, sizes, and amounts used in the finish coats, and the condition of the panels at the end of 12 months' exposure has already been published.[2] However, at the end of three

[2] Emley and Berger, J. Am. Ceramic Soc., vol. 6, No. 9, p. 1007; 1923.

years; that is, on March 4, 1925, in order to accelerate, if possible, any hydration effect, the panels were thoroughly soaked and allowed to dry before examination. This treatment seemed to have the desired effect and while there have been slight changes in some of the panels since the application of the water, their condition when last examined, at the end of four years, was not apparently different from that at the end of three years.

The condition of the panels at the end of four years justifies the following statements relative to the materials employed:

Core (ground limestone) and mica, when added in the amount of 10 per cent by weight of the finish cost, have no effect, regardless of size.

Magnesium sulphate and sodium chloride cause efflorescence.

Iron carbonate, iron sulphide (pyrite), and lime burned during hydration tend to cause unsoundness, but not seriously if fine.

Overburned lime will always give trouble, regardless of size.

Tannic acid is deleterious for special reasons.

Two of the hydrates submitted were found to be unsound.

As stated previously, there have been some changes in the condition of the panels during the second, third, and fourth years. However, it is not believed that these have been sufficient to justify any changes in the recommended basis for a specification for the soundness of hydrated lime, which is repeated for emphasis:

"Examine microscopically to insure the absence of calcium oxide (index of refraction=1.81).

"Wash the sample through a No. 50 sieve. Dry and weigh the residue and figure it as per cent of the sample. If the residue is more than 5 per cent, it should be analyzed. If this is found to contain less than 90 per cent calcium carbonate, the shipment represented by the sample should be rejected.

"Pyrite can hardly occur in lime, but may be a constituent of the sand. A specification for sand is required, which should also carry limits on the quantity of salt and organic matter permissible."

FIRE TESTS WITH SHEET-STEEL GARAGES

Two tests to determine the stability under fire conditions of all-steel garages and the hazard to adjacent buildings accompanying a complete burning out of contents have been completed recently at the bureau. The tests were conducted at the request of the Sheet Steel Trade Extension Committee, which constructed the garages for the tests. The minimum allowable distance between such garages and the lot line or adjacent buildings varies widely in the building codes and fire regulations of different cities. Where space is limited this rule often is the deciding factor in the choice of garage construction.

The garage burned out was 18 by 18 feet in horizontal dimensions with gable roof, and built to accommodate two cars. The sheet-metal roof was supported by the steel end framing and one center steel truss. The contents for each test consisted in part of two old five or seven passenger automobiles near the medium in weigh and size, having wood framed bodies; one touring and one sedan. A 10-foot workbench, shelves, paper, waste barrel, and lumber on the floor and on the steel framing overhead gave an additional combustible content of about 1,000 pounds. There was about 14 gallons of gasoline in the tanks of the two cars and the crank cases were filled before the test. From information available the combustible contents were somewhat above the average.

In the first test, three wood frame walls finished with old lap siding, were placed adjacent to three sides of the garage, 12, 18, and 24 inches, respectively, from the wall lines. Temperatures were measured inside of the garage and on the exposed surfaces of the wood walls. The weather was warm (86° F.) and calm at the time of the test. The fire was started in the front of one car and within 15 minutes both cars were burning actively. The average

temperature within the garage rose to a maximum of 571° C. (1,060° F.) in 70 minutes, after which it fell slowly, being 336° C. (637° F.) at 2 hours, 219° C. (426° F.) at 3 hours, and 129° C. (264° F.) at 4 hours. The maximum temperature measured inside of the garage at any one point was 726° C. (1,339° F.). One of the double doors of the garage was kept partly open during the test to admit enough air for free combustion. Everything combustible within was completely consumed, even the oil in the crank cases. Glass and the more fusible metals were melted. The gasoline in the tanks vaporized and burned quietly without any explosive effects. The garage walls and roof did not buckle or open up appreciably during the fire. The building effectively restrained the flames and hot gases within, the heat exposure to the wooden walls being almost wholly from radiation. These ignited in from 30 minutes to 1 hour after the start of the test, depending on the distance from the garage walls. The fire on each could be kept down with a 5-gallon pump type fire extinguisher that was refilled with water at intervals.

In the second test two wooden walls were spaced, respectively, 3 and 5 feet from two of the garage walls, and near the third wall was placed a sheet-metal garage with part of the exposed wall 2 feet and part of it 3 feet from the wall of the garage to be burned out. The exposed metal garage had a wood bench against its exposed wall with oily waste on it in contact with the metal of the wall and housed a car with gasoline in its tank and carburetor. The fire inside of the two-car garage attained about the same intensity and duration as in the first test. The wooden wall spaced 3 feet from the garage ignited 64 minutes after the start of the test and small blazes on this wall developed at intervals during the next 30 minutes. They were all easily quenched with the hand-pump extinguisher. The wall spaced 5 feet from the garage did not ignite, but a temperature developed which was high enough to cause smoking of the boards about 5 feet above the ground. The maximum temperature indicated by thermocouples against the exposed face of this wall was 182° C. (360° F.), although it is probable that portions of the wall were somewhat hotter. After exposures to heat of durations comparable with those obtaining in these tests, wood ignites at temperatures near 250° C. (482° F.).

The measured temperatures inside of the exposed sheet-metal garage did not exceed 73° C. (163° F.) as measured against the inside face of the sheet-metal wall placed 2 feet from the burning garage. The temperature inside of the car in this garage did not exceed 28° C. (82° F.), the outside air temperature during test being 21° C. (70° F.). The temperature of the gasoline in the tank of this car rose only 1.6° C. (3° F.), and the temperature near the carburetor 2.7° C. (5° F.).

The interpretation of results depends on the assumptions relative to the degree of hazard to which a minor building, such as a garage, may expose a major building or another garage. If exposure of a degree that can be controlled with minor fire-fighting equipment or effort is to be permitted, it is apparent that the all-steel garage can be placed as close as 1 foot from the lot line for all walls except the door side, provided any windows in the wall next to the lot line or exposed building have fixed metal frames glazed with wire glass. Under the same conditions an all-steel garage would be no hazard to a similar garage 2 feet away.

The fact that there was little buckling or other distortion of the sheet steel and framing members can be attributed to the low loads present during test. These buildings must necessarily be designed for wind and snow loads that give stresses several times higher than those from the dead load of the building itself.

These tests as well as some preliminary trials with the burning of gasoline in automobile gasoline tanks indicate that there is little probability of explosions occurring. If pressure develops because of vaporization of the gasoline

it is likely to be relieved before a high intensity is built up by failure of the joints of the tank, forcing of carburetor or vacuum tank, or melting of soldered connections.

RADIATION FROM THE CARBON ARC

The bureau is investigating the radiation from the carbon arc, a matter of great importance in the treatment of diseases by exposure to light, especially sunlight. However, sunlight can not always be obtained, hence the demand for an artificial source approaching sunlight in its characteristics.

The investigation is being made in duplicate: (1) By mapping the ultraviolet spectrum by means of a quartz spectroradiometer, and (2) by measuring the spectral components of the total radiation emitted by the arc, by using a thermopile and screens which completely absorb certain spectral regions and freely transmit others.

Thus far studies have been made of the standard carbons on the market, viz, "white flame," "red flame," "yellow flame," "blue flame," and "neutral core" carbon electrodes; also several special carbons with cores of nickel, tungsten, etc. The effect of varying the current has been studied, using 15, 30, 60, 90, and 122 amperes.

The high-intensity arc (120 amperes) has been found to be closest to the sun in spectral composition. It emits considerable radiation of wave lengths longer than 4μ, which are not in the solar beam, but this can be eliminated easily by using a window of fused quartz, which absorbs the long infrared rays.

SURFACE SIZING PAPER

Fine papers are ordinarily sized to obtain a smooth, nonabsorbent surface by immersion in a bath of animal glue. Such surface sizing also effects marked changes in the strength and resistance to wear of paper so treated.

During investigational work on the manufacture of rag papers in the bureau's experimental paper mill, papers were produced weighing about 22.5 pounds, 17 by 22 inches, 500, that had a minimum folding endurance of approximately 2,500 double folds for a 100 per cent cotton fiber paper and up to 5,000 double folds for a paper of 75:25 linen-cotton fiber ratio, these tests being made on the waterleaf (unsized) papers. Ordinary tub sizing with medium grades of animal glue added generally from 1,000 to 1,500 more double folds to the tests of the waterleaf papers. These folding endurance tests were made at 65 per cent relative humidity. The results, in general, of the study of the effect of surface sizing made in the course of this work indicate that with any given paper, (1) the bursting strength increases with increased retention of the glue; (2) the folding endurance increases with increasing glue content to a certain point and then decreases; (3) the resistance to water and to wet rubbing of glue-sized papers may be markedly increased by treatment with glue hardening or tanning materials, such as formaldehyde, but such treatment requires careful control, lest the folding endurance be adversely affected; (4) the folding endurance of both unsized papers and surface-sized papers, whether or not hardening agents have been used, may be increased by the addition of certain softening agents or lubricants, such as glycerine or nondrying oils; and (5) a limited number of tests check outside opinions that the effect of glycerine treatments, as ordinarily applied, on the folding endurance of paper is comparatively short lived. A number of variables in the paper-making processes affect the degree of sizing imparted by immersion of the paper in animal glue and to these must be added the influence of variations in the size itself. Printing tests by the wet-intaglio process on experimental rag papers lead to the tentative conclusion that tub sizing with glue prepared from hide cuttings by paper manufacturers does not produce papers that differ noticeably from those tub-sized with commercial glues. Tests made by the standard methods of the National Association of Glue Manufac-

turers on several samples of size made from hide cuttings in paper mills show that their jell strength and viscosity are similar to those of medium grade commercial glues. It would appear that the use of uniform commercial glues of known characteristics should aid in maintaining control of some of the variables of the tub-sizing process. The successful use of the standard glue testing methods by the Government Printing Office in their specifications for glues used in printing and binding processes, suggests the possibility of drawing specifications for commercial tub-sizing glues to meet the local requirements of individual mills.

This preliminary study shows that in the application of tub sizing and chemical treatment processes to different types of papers, there is required a broad study and exact knowledge of all the factors involved in order to control the improvement of qualities of papers along desired lines. It is planned to study further in the bureau's paper mill some of the factors influencing glue surface sizing.

EFFECT OF TUNGSTEN DEPOSIT ON ELECTRIC LAMP BULB

Recently the bureau removed from service an electric lamp, the life history of which had been carefully recorded. The bulb was cut from the base, and a small electric lamp placed inside the blackened bulb. The effect of the tungsten deposit on the observed color temperature of the source and on the transmission of the glass was measured at various places through the bulb. The data will have an important bearing on the use of gas-filled lamps as standards of color or intensity.

PROPERTIES OF BAG LEATHER

Bag leather is an important article of commerce, used in the manufacture of bags and cases for many purposes. For instance, it is largely used by the War Department for saddle bags and cases, by the Post Office Department for letter carriers' satchels, and by the other agencies for various types of containers. Bag leather constitutes the grain split from a cow or steer hide and varies in thickness from 3/64 inch to 1/8 inch, depending upon the use to be made of it. Most commercial leather runs about 5/64 inch thick. In connection with the development of quality standards for bag leather for the use of the Federal Specifications Board, a number of sides of commercial bag leather were examined for their physical and chemical properties. At the same time sides of bag leather containing high amounts of grease were also examined. The results showed that the leathers with high grease contents had greater tearing and tensile strength than the commercial material with lower grease contents. The average results for certain of the important properties are as follows:

Kind of leather	Grease	Acid	Ash	Tensile strength
	Per cent	*Per cent*	*Per cent*	*Lbs./in.²*
Commercial	8.00	0.42	0.73	3,480
High grease	14.80	.63	.78	3,940

The results for grease content on commercial leather showed a lack of any recognized standard, the amount varying from a minimum of 4 per cent to a maximum of 12 per cent. From these data limiting values will be selected for use in setting up a Federal specification for bag leather for the use of the various Government departments. The Tanners' Council of America is cooperating in this work through a committee of bag-leather tanners.

JUNE, 1926, PUBLICATIONS

Additions to "Supplementary List of Publications of the Bureau of Standards" (Beginning July 1, 1925)

Scientific Papers

S523. Wind pressures on structures; Hugh L. Dryden and George C. Hill. Price, 20 cents.

S524. Measurements on the thermal expansion of fused silica; Wilmer Souder and Peter Hidnert. Price, 10 cents.

S526. Transmission and absorption of sound by some building materials; E. A. Eckhardt and V. L. Chrisler. Price, 15 cents.

Technologic Papers

T315. Nondestructive testing of wire hoisting rope by magnetic analysis; R. L. Sanford. Price, 10 cents.

Simplified Practice Recommendations (Elimination of Waste)

R28. Sheet steel (first revision). Price, 5 cents.

R40. Hospital chinaware. Price, 5 cents.

R45. Grinding wheels. Price, 10 cents.

R47. Cut tacks and small cut nails. Price, 5 cents.

R49. Sidewalk, floor, and roof lights. Price, 5 cents.

OUTSIDE PUBLICATIONS

Note on decay of RaE. L. F. Curtiss; Physical Review, vol. 27, p. 672, June, 1926.

The effect of an electric field applied to a photographic plate during exposure. A. E. Ruark; Science, vol. 63, p. 376, June 4, 1926.

The fine structure and Zeeman effect of complex mercury lines. A. E. Ruark; Philosophical Magazine, vol. 61, p. 977, 1926.

Oxygen affects charcoal iron. J. R. Eckman, L. Jordan, and W. E. Jominy; Foundry, vol. 54, p. 506, 1926.

Some characteristics of quenching curves. H. J. French and O. Z. Klopsch; Transactions, American Society for Steel Treating; vol. 9, p. 857, 1926.

Application of heat-treated steels to industrial uses. (Two-page abstract of lecture by H. J. French.) Transactions, American Society for Steel Treating, vol. 9, p. 997, 1926.

Written discussion by S. Epstein of paper on irregular carburization of iron and iron alloys. Transactions, American Society for Steel Treating, vol. 9, p. 920, 1926.

A laboratory high-frequency vacuum furnace. J. R. Cain and A. A. Peterson; Transactions, American Electrochemical Society, vol. 48, p. 139, 1926.

Strain detection in mild steel by wash coating. R. S. Johnston; Proceedings, British Iron and Steel Institute, Vol. CXII, No. II, p. 342, 1925.

How to investigate welded tanks. H. L. Whittemore; Journal American Welding Society, vol. 5, No. 5, p. 23, May, 1926.

Comparative tests of some American and German fire-clay brick. R. F. Geller and W. L. Pendergast; Journal American Ceramic Society; vol. 9, No. 6, June, 1926.

The effect of certain materials in the finish coat of plaster. J. M. Porter; Appendix I, 1926 Report of Committee C–7 on Lime, American Society for Testing Materials.

The fire resistance of clay hollow load-bearing wall tile. H. D. Foster; Proceedings Twelfth Annual Meeting Building Officials' Conference, pp. 103–110, 1926.

The structural factor in fire prevention. S. H. Ingberg; Proceedings Twelfth Annual Meeting Building Officials' Conference, pp. 126–132, 1926.

Paper research literature, VII, 1st supplement. C. J. West and B. W. Scribner. Paper Trade Journal, May 20, 1926.

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